THE CIRCULATORY APPARATUS IN GENERAL PARALYSIS OF THE INSANE.

BY

T. DUNCAN GREENLEES, M.D. EDIN., F.R.S.E.,

GRAHAMSTOWN, SOUTH AFRICA.

Reprinted from the "Caledonian Medical Journal" for April, 1904.

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General paralysis, ever since Bayle specially directed attention to it in 1822, has maintained its interest among pathologists, and, although few diseases have had so much investigation devoted to them, there still remain many points both in its etiology and in its pathology that require clearing up, and any contribution with this object must be welcomed. Some say that general paralysis is *always* syphilitic in its origin; others, again, maintain that alcohol, either alone or combined with one or other factors, is its chief cause; and, finally, there are supporters to such factors in its production as sexual excesses, traumatisms, and toxic poisoning.

With such varied opinions—each, it must be admitted, supported by strong and presumably reliable evidence—whatever is the cause of this fatal disease, it cannot be doubted that grave structural changes occur in other tissues than the brain and its membranes—the chief seats of the lesions which are most commonly found. Indeed, there is hardly an organ or tissue in the body that remains unaffected, and the circulatory apparatus especially presents structural alterations in its entire extent. These lesions may be the direct cause of the disease, they may be as a consequence of changes occurring elsewhere, or they may exist simply as concurrent or independent conditions. In the following pages an endeavour is made to show the relations that exist between the circulatory apparatus and general paralysis—the condition of the heart, vessels, and pulse, being dealt with separately.

Heart disease in general paralysis.—In an unpublished thesis on "The Circulation in Insanity," I have already shown that cardiac disease exists in 15 per cent, and that functional cardiac derangement, short of organic disease, is found in 43½ per cent of all cases of general paralysis, as proved by a systematic examination of the patients on their admission to an asylum. Heart disease, on the other hand, was found to

exist in 12·94 per cent of all cases of insanity. It is thus evident that heart disease is more common among cases of the insanity of general paralysis than among the other types of insanity. Of the valves most frequently affected it was noted that disease of the aortic cusps exceeded either mitral or tricuspid disease.

Degeneration of the cardiac muscle is occasional, and acute fatty degeneration of the muscular fibre has been specially described by Campbell,[1] who believes it to be due to changes in the motor end-plates; and Mott[2] ascribes this condition to imperfect metabolism, and is of opinion that it is indirectly caused by auto-intoxication, seeing it occurs most frequently in cases ending in bedsores, gangrene of the lungs, &c.

During the past thirteen years autopsies were made in Grahamstown Asylum on 50 men and 4 women who had died from general paralysis. The average age at death was, for men, 41; and for women, 45 years. The average weight of the heart was 8·46 oz. for men, and 5·50 oz. for women. The aortic valves were shrivelled and incompetent in 11 cases, and in only 1 was the mitral valve likewise diseased. "Milk-spots"—evidences of old pericarditis—existed in 4 cases, and the larger arteries were noted as atheromatous in 23. Pachymeningitis hæmorrhagica, essentially a vascular disease, was found in 7 cases—12·9 per cent of the total. Thickening and hypertrophy of the walls of the left ventricle were common conditions, even although the actual weight of the heart did not appear to be even, in these cases, normal.

The arteries in general paralysis.—When we consider the comparatively early age at which death is common in general paralysis, it is interesting to note the frequency with which thickening of the arterial coats, more especially the muscular, is found. This simple muscular hypertrophy is common in ordinary cases of general paralysis, but in the syphilitic, and perhaps also in the alcoholic, types of the disease actual atheromatous degeneration of the arterial tunics is frequent. Indeed, the condition of the arteries reminds one of that common to old age; this fact lends some force to the theory, advanced by some, that general paralysis, a disease essentially of robust manhood, is simply premature senility.

Considered pathologically, we thus have two forms of general paralysis—the *first*, the syphilitic, and perhaps the alcoholic as well, with atheromatous degeneration of the arterial coats; and the *second*, the non-syphilitic type, where

[1] A. Campbell, *Journal of Mental Science*, April, 1894.
[2] F. W. Mott, *Archives of Neurology*, vol. i, p. 195.

mainly a simple hypertrophy of the arterial muscular tunic is found. This general vascular muscular hypertrophy—for it has been shown that the left ventricle also participates in the change—indicates some abnormal resistance to the circulation; the resistance in this disease being found specially in the peripheral arterioles of the brain. The existence of this hypertrophy and arterial tension suggests grave defects in the vital processes of nourishment and excretion, as well in the brain as in the other organs of the body.

I frequently found the basilar arteries diseased, their walls thickened, and the vessels resistant to pressure, feeling tense and "gritty" under the finger, often irregular in contour, and presenting occasional localised dilatations just short of aneurysms. Such diseased conditions of the main arteries to the brain must necessarily seriously interfere with its functions.

The chief pathological interest of this disease is, however, centred in the cerebral arteries and arterioles, for it is here we find evidences of lesions that, from their presence, no doubt give rise to the grave mental and somatic symptoms that characterise general paralysis. A brief description of the normal structure of the minute cerebral vessels will assist us in understanding the alterations found in this disease.

Minute structure of the cerebral blood-vessels.—The medium sized and smaller arteries of the brain possess four coats—the endothelial, the elastic, the muscular, and the adventitial. Th. Ducke[1] describes two, and, in many of the larger vessels, three additional tunics; while Bevan Lewis[2] only recognises three coats—the first two, according to him, being only one coat.

1. The endothelial coat (*tunica intima*) is the innermost lining membrane of the vessel, and is continuous throughout the entire vascular system. It consists of a layer of endothelial cells, the outline of which can be demonstrated by the "silver process," which stains the intercellular substance black. The nuclei of these cells are oval or oblong in shape, and are arranged with their long axis corresponding with the long axis of the vessel.

2. The elastic coat (*tunica fenestrata*) lies outside the endothelial tunic, and is a "non-nucleated, irregular, and reticulated web of compact bands," in which bright spots are seen, stated to be stomata or foramina by Ducke. These spots are most frequently found immediately above, or in the

[1] Th. Ducke, *American Journal of Insanity.*

[2] Bevan Lewis, *Mental Diseases*, first edition, p. 75.

neighbourhood of, the nuclei belonging to the subjacent endothelial cells ; they are rounded in shape, and possibly, according to Lewis, allow of the escape of altered leucocytes in the capillaries.

3. The muscular coat (*tunica muscularis*) consists of bundles of circularly arranged non-striated muscular fibres, and the thickness of the vessel depends in a great measure on the number of these fibres. The nuclei are oval in shape, sometimes kidney-shaped, and are arranged transversely to the long axis of the vessel. Interwoven with the muscular bundles are elastic bands and connective tissue corpuscles, the nuclei

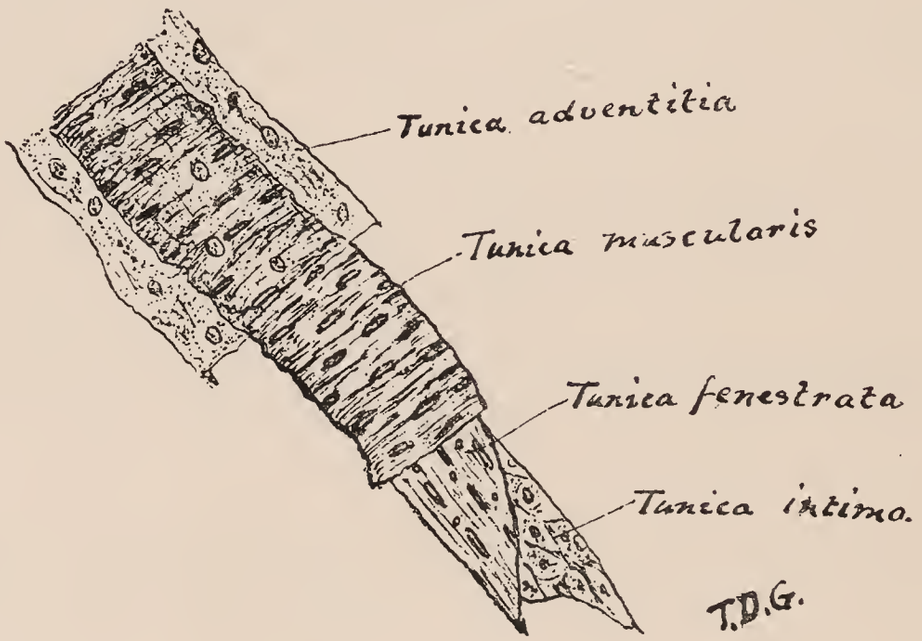

Fig. 1.

Showing diagrammatically ultimate structure of minute cerebral artery.

of which vary in shape, and are demonstrated by the usual stains.

4. The adventitial coat (*tunica adventitia*) is composed of broad connective tissue elements, and is closely apposed to the muscular coat; its outline presents slight dilatations and irregularities here and there, especially at the points of bifurcation of the vessels, where it bridges over the angles made by the division of the vessels into two branches. In the smallest vessels this tunic forms a delicate, and apparently structureless, membrane surrounding the vessel. In certain diseased conditions, and especially in general paralysis, the tunica adventitia becomes separated from the subjacent muscular coat, leaving a space between the two which has been called the "adventitial lymph space" of Robin and Virchow;

this space must not be mistaken for the perivascular space which occurs normally. The nuclei of the adventitial sheath are oblong in shape, but more rounded in its innermost layers. This membrane is a direct continuation of the pia mater, the fibres of which may be seen to dip down into the cortex along with the vessels which they surround.

The perivascular space is the interval between the tunica adventitia and the brain substance, and has been termed the "lymph space" of His. In fresh sections of the brain these

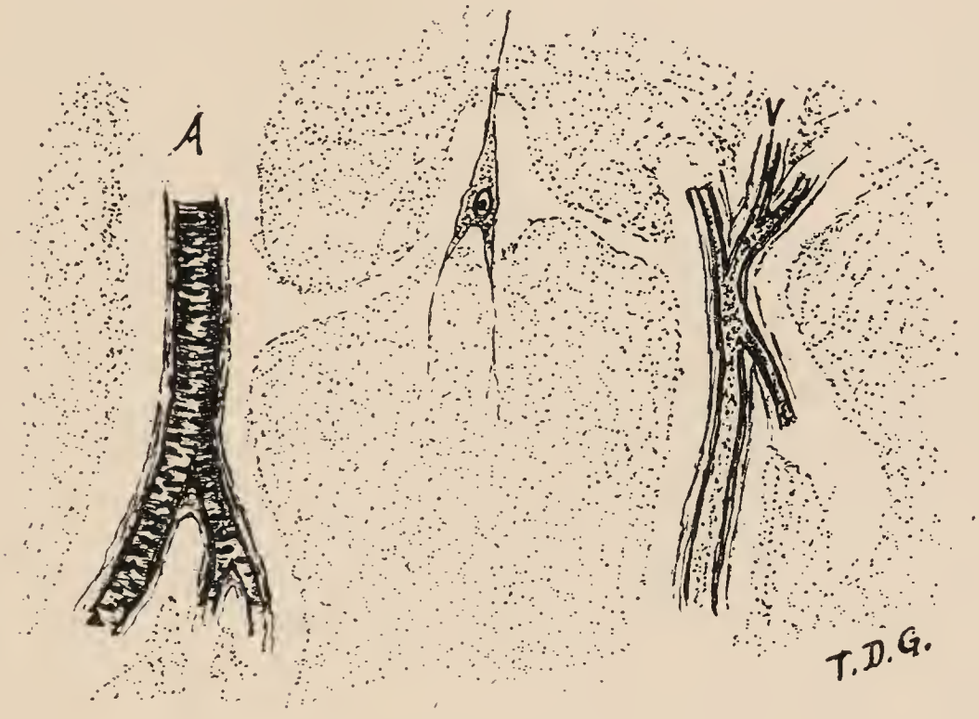

Fig. 2.

Showing scheme of relationship between minute cerebral artery, a cell, and vein, by means of the perivascular and pericellular spaces. *A*, artery; *V*, vein.

spaces are not so well demonstrated as they are in hardened sections, but they are specially evident (even in fresh sections) in atrophy of the brain. Microscopically they are observed to communicate with spaces which surround the cerebral cells, called the "pericellular spaces." No lining membrane, apart from that formed by the adventitial coat on the one side, and the brain substance on the other, has been described, although Batty Tuke[1] shows these spaces as if lined with epithelial cells.

The fact that the perivascular spaces are more evident in hardened sections than in fresh preparations of the brain proves, according to Obersteiner,[2] who first drew attention to

[1] Batty Tuke, *Morisonian Lectures—Brain Exhaustion.*
[2] Obersteiner, *Anatomy of the Nervous System.*

them, the power the brain possesses during life to fluctuations, even although enclosed in "a closed box;" such fluctuations being due to alterations and variations in the blood-pressure; for, when a vessel within the cranial cavity is distended with an excess of blood, the perivascular space is naturally diminished, and when the vessel's contents are reduced in volume the perivascular space is increased. In cerebral atrophy, such as is found in general paralysis and senility, the perivascular spaces are very evident, while in cerebral congestion, such as is frequently found in epilepsy, the vessels seem to completely fill up the spaces, and it would almost appear as if the presence of these perivascular spaces permitted of a certain "ebb and flow" of the circulating blood within the cranium, and thus the pressure, under normal circumstances, is regulated to a nicety.

The free communication between the perivascular and pericellular spaces suggests the method of cellular nourishment, and Obersteiner noted lymphoid corpuscles floating within this space.

As the arteries dip down from the pia mater into the cortex they rapidly diminish in size, and ultimately become *arterioles*, which are devoid of a muscular coat. The cerebral capillaries consist essentially of two coats, the inner of which is a delicate endothelial membrane continuous with the tunica intima of the larger vessels, and an external tunic, the adventitial coat, which here is more delicate, and consists of "longitudinally arranged connective tissue fibres and connective tissue corpuscles" (Ford Robertson[1]).

The *cerebral veins* possess three coats—an outer, the adventitial sheath; the middle coat, consisting of bundles of connective tissue fibres; and an internal endothelial lining membrane.

It has, I think, been demonstrated that the cerebral blood-vessels do not differ from the vessels in other parts of the body as regards their *nerve supply*. Several observers, working by different methods and in different directions, have shown the existence of nerve fibres and nerve plexuses in both the adventitial and muscular tunics.

Changes in the cerebral arteries and arterioles in general paralysis.—In a series of observations which I made some years ago on the cerebral vessels in this disease, the following methods were adopted to ascertain the changes:—

1. The smaller arteries were carefully traced from the pia mater as far into the cortex as it was possible to dissect them;

[1] Ford Robertson, *Pathology of Insanity*, p. 134.

the vessel and its branches were then teased out on a slide, stained and mounted, and examined microscopically while fresh. In some delicate tracings the ultimate structure of the arterioles was observed.

2. Fresh sections of the brain were made, stained, and mounted. By this method the sieve-like appearance, due to the perivascular and pericellular spaces, from which the contents had either fallen out or been removed in making the section, was noted, and this condition—so common in general paralysis—was even visible to the naked eye.

3. Finally, sections were made in the usual way after hardening portions of the brain tissue, selecting two sites—the frontal portion of the cortex and the basal ganglia for uniformity. In general paralysis the empty spaces, giving a sieve-like appearance to the sections, were even more apparent than in the fresh sections, owing to shrinking of the cerebral tissue in the process of hardening.

An examination of the cerebral vessels by all these methods reveals certain alterations in general paralysis which are practically constant, and which are so rare in other cerebral diseases, that we are forced to the conclusion that they form the most important factor in the pathology of this disease.

Quoting from a paper written nineteen years ago:—"In small arteries, which were teased from the pia mater inwards some considerable distance in the convolutions, I found a slight degree of tortuosity, and in places localised dilatations, but neither of these conditions occurred to the extent usually described in this disease. The vascular walls were generally thickened, more, however, from hypertrophy of the muscular tunic than by atheromatous deposit. The adventitial sheath formed a loose enveloping membrane to the vessel and all its branches, with wide open spaces at the points of bifurcation, and here and there along the course of the artery bulging out, leaving a considerable interval between the vessel and its sheath. Within and upon the sheath, more especially at the angles caused by the bifurcation of the vessel, were deposited small particles of pigment and minute globules of fat. The pigment varied in colour from a primrose tint to a deep mahogany brown."

Mickle[1] and Ford Robertson[2] discuss fully the pathological changes in the cerebral arteries in general paralysis, dealing specially with the following morbid conditions; the vessel being full of blood corpuscles, an increase of nuclei in the arterial walls, more particularly in the perivascular sheath,

[1] J. Mickle, *General Paralysis*, second edition.
[2] Ford Robertson, *Pathology of Insanity*, p. 134.

lymph corpuscles, &c. Within the perivascular spaces, pigmentary and other deposits within and around the vascular walls, general thickening of one or other of the vascular tunics, dilatations, tortuosities, and varicosities of the arterioles; various degenerations, such as colloid and amyloid, of the minute vessels—conditions, it may be mentioned, not confined to general paralysis; and, finally, obliteration of the arterioles, or the formation of new vessels (Fig. 3).

Any one or more of the above changes may be found in a typical example of general paralysis; but it must not be understood that the presence or absence of these pathological

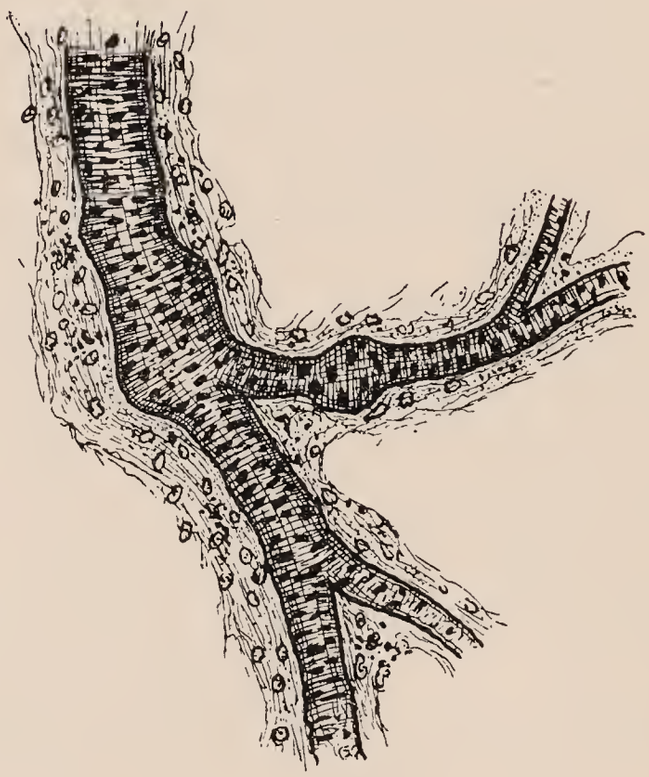

Fig. 3.

Showing morbid changes in minute cerebral artery in general paralysis.

changes constitutes a dogmatic diagnosis, although we are almost sure to meet with several of these changes in any prolonged case.

It may be asserted that as varieties are found clinically in cases of general paralysis, so may we find varieties in the pathological alterations, especially as they affect the vascular system.

With such interesting and important vascular changes common to this disease, it may not be out of place discussing several of the theories that have recently been advanced to explain its etiology and pathology.

Bevan Lewis holds that general paralysis is an inflammatory

process, having its origin in the lymph sheaths of the pial vessels, and that the progress of the disease is as follows:—

1. A stage of inflammatory change in the tunica adventitia, with excessive nuclear proliferation, profound changes in the vascular channels, and trophic changes induced in the tissues around.

2. A stage of extraordinary development of the lymph connective tissue system of the brain, with a parallel degeneration and disappearance of nerve elements, the axis cylinders of which are denuded.

3. A stage of general fibrillation, with shrinking and extreme atrophy of the parts involved.

Ford Robertson[1] has recently advanced the theory that general paralysis is essentially toxic in its origin, and at first he ascribed the cause to the *bacillus coli*, which he found in large numbers in the gastro-intestinal tract.

But as this bacillus is to be found likewise in cases that undoubtedly are *not* examples of general paralysis, this theory had to be abandoned, and later[2] he has described the Klebs-Löffler bacillus, or a bacillus indistinguishable from it, and which he found in the respiratory and gastro-intestinal tracts, as well as in other parts of the body in these cases, as being the primary cause of this disease. Its presence in the brain indicates, according to this observer, "a terminal blood infection." He further states "that this bacillus exercises a pathogenic action in general paralysis, . . . the disease is the result of a chronic toxic infection from the respiratory and alimentary tracts, permitted by general and local impairment of the defences against bacteria . . . which give the disease its special paralytic character."

He is more guarded in his latest contribution to this interesting subject, for he says[3] "it would be premature to discuss the bearing of these observations upon the question of the pathogenesis of general paralysis."

Of course, were this diphtheroid bacillus the specific organism in general paralysis we should expect to find it in the earliest stages of the disease, as has been pointed out by Mott, but this has not yet been done; further, as shown by Andriezen, cystitis and other suppurative processes, common to this disease, and which are, according to Robertson's hypothesis, the consequences of bacillary infection, may be simply "subterminal infective conditions."

That general paralysis is toxic in its origin remains to be

[1] Ford Robertson, *British Medical Journal*, 29th June, 1903.
[2] Ford Robertson, *Review of Neurology*, May, 1903.
[3] Ford Robertson, *Review of Neurology*, July, 1903.

proved, but certainly many of the symptoms in the course of the disease, and several points in its pathology, lend support to a bacterial infection theory; among these symptoms may be mentioned the readiness general paralytics exhibit to the formation of bedsores and abscesses, as well as by the marked and irregularly recurring attacks of leucocytosis, as was first noted by Lewis Bruce.[1]

Granted we have a bacillus circulating with the blood-stream within the cerebral vessels, and given "a local or general impairment of the defences against bacteria"—perhaps from hereditary predisposition rendering unstable the cerebral tissues—then it would seem as if the action of the bacillus was primarily upon the walls of the arterioles.

Ford Robertson's theories support the opinions held by Bevan Lewis that this disease is essentially a blood-vascular one, and all the evidence available indicates that its progress is somewhat as follows:—The introduction from without of some toxin—it may be Klebs-Löffler bacillus—producing a stasis in the blood-stream, while the irritation, caused by the presence of the bacillus, induces proliferation of the nuclei of the tunica adventitia, and, to a lesser extent, the nuclei of the other arterial coats as well. The escape of plasma into the subadventitial space, so that the adventitial sheath becomes completely separated from the muscular coat, exercises pressure upon the walls of the vessel, and this, in its turn, gives rise to muscular hypertrophy, compensatory in nature. When compensation fails we then get engorgement of the surrounding perivascular and pericellular channels, and, finally, effusion into the cerebral tissue, causing dropsy of the brain. This general irritative process finally causes an increase in the connective tissue elements of the brain, with consequent pressure-atrophy of the nerves and cells, and, as the last stage of all, there is complete obliteration of the neural elements in extensive areas of the brain.

A study of the clinical symptoms of general paralysis in its earliest stages, with its delicate mental and motor manifestations, would seem to indicate an early impairment in the functions of the cerebral cells, and such change is evidently of an irritative character; it is reasonable to infer that this cellular irritation is caused by a foreign body—shall we call it a bacillus?—floating in the pericellular channels, and exercising a direct intoxicating or poisoning effect upon the cell itself. As this poisoning is a continuous process, and as it is evident that the poison is an accumulative one, the cell ultimately dies, and terminal dementia, as regards the

[1] Lewis Bruce, *British Medical Journal*, 1901.

mind, and general paralysis, as regards the body, result, being the manifestations of the death of the cerebral neural elements.

Blood-pressure in general paralysis.—In this connection it may be of interest to note briefly that Mott[1] found the arterial pressure, as measured by the sphygmometer, to be high in the first two stages of the disease, being even as high as 200, 120 being considered as normal, in some cases. In the last stage, and after a series of "congestive" seizures, the arterial pressure falls even to below normal owing to failure of the heart's action, although it may actually rise during the seizure itself. These observations of Mott are, in part, verified by those I have made with the sphygmograph in this disease.

The pulse in general paralysis.—Mickle[2] states that the pulse is full and hard in the early stage, while in some cases both it and the heart-beats may be quite normal. The relationship between the pulse-rate and the temperature are, according to him, not constant, and unlike that usually found; for example, a rise of temperature was frequently noted with a decreased pulse-rate; or, conversely, while the temperature fell, the pulse increased in frequency. He also noted that the evening pulse-rate exceeded that of the morning by an average of $5\frac{1}{2}$ beats—a rate exceeding that usually found in healthy persons.

Whitwell[3] refers to the pulse in general paralysis as presenting low tension in the majority of cases, increased tension in the second stage, and suggests an analogy between the increased tension of this disease and others of a similar nature, such as locomotor ataxia.

Dr. Goodall,[4] on the other hand, says the pulse in general paralysis does not present anything characteristic—a statement certainly not borne out by the investigations of numerous and perfectly independent observers.

Frequency of the pulse.—In a large number of observations made some years ago, I ascertained that, whereas in health the evening pulse-rate is slower than that of the morning, such variation is less marked in general paralysis under

[1] F. W. Mott, *Arch. Neurology*, vol. i, p. 291.
[2] J. Mickle, *General Paralysis*, second edition.
[3] J. Whitwell, *Dict. Psych. Med.* (Tuke), vol. ii, p. 1047.
[4] E. Goodall, Clifford Allbutt's *System of Medicine*, Article "General Paralysis."

ordinary circumstances. When, however, "congestive" attacks occur in the course of the disease, then both the pulse and temperature are higher in the evening.

This table shows graphically the relationship between the pulse in health and general paralysis—the average having been taken from a large number of observations:—

Pulse in	Males.		Females.		Total.	
	A.M.	P.M.	A.M.	P.M.	A.M.	P.M.
General paralysis, .	82·26	81·39	80·25	80·75	80·60	79·72
Health, . . .	82·0	74·0	87·0	80·0	78·0	83·0

Pulse rhythm.—Unless actual organic or functional cardiac disease exists, the pulse is, as a rule, regular, except in the last stage of the disease, and then whatever irregularity is noted is chiefly due to the irregular and fluttering action of a failing heart.

Force of the pulse.—In considering the *force* of the pulse in any disease we have to bear in mind two factors:—(1) The ventricular systole, and (2) the volume of blood discharged into the vessels. The force may be modified by a feeble systole, as well as by resistance to the blood flow. While elasticity of the arterial walls may produce low tension, rigidity gives rise to increased tension. Further, the tension may be increased by resistance in the peripheral arterioles, and which may occur even although the ventricular systole is powerful. The *vis-a-fronte* as well as the *vis-a-tergo* plays an important part in influencing the actual tension of the vascular system.

Although the finger demonstrates these various conditions of the pulse, much assistance is obtained in the study of the pulse by the use of some graphic instrument for recording the details of each beat for purposes of comparison and as a permanent record. For these purposes the *sphygmograph* is indispensable. Much discussion has taken place as to the various instruments recommended, but it would seem to me that, in any series of observations, were the one sphygmograph used, and used systematically at stated times and under similar and corresponding conditions, the results obtained would be more scientific than those obtained in an erratic manner, using any instrument most convenient at the moment.

The following observations are the results of the study of pulse-tracings taken from twenty-nine general paralytics at all stages of the disease, Dudgeon's instrument being the one used. In some cases tracings were obtained from the same individual at different stages of the disease, showing certain modifications in the tracings which were undoubtedly caused by the disease itself, while several tracings were obtained, and one of which is here illustrated, from patients in the very last stage of the disease, when, as a matter of fact, they were actually moribund.

A careful study of the tracings illustrating this paper will reveal a marked similarity in the tracings referring to each stage of the disease, but differences at once become apparent when the tracings of different stages are compared with each other.

It will, therefore, be advisable to consider this subject under the various stages characteristic of the clinical history of general paralysis.

First stage.—During this stage the patient is in a condition of exaggerated happiness, contentment, and extravagance, and there is always, or nearly so, some little excitement, accompanied by irritation if thwarted in any way.

At the onset of the disease the pulse is more rapid than normal, feels bounding to the finger, is evidently of low tension, and dicrotism is occasionally perceptible.

The pulse-tracings show these characteristics admirably, and so similar are the sphygmograms during this stage that

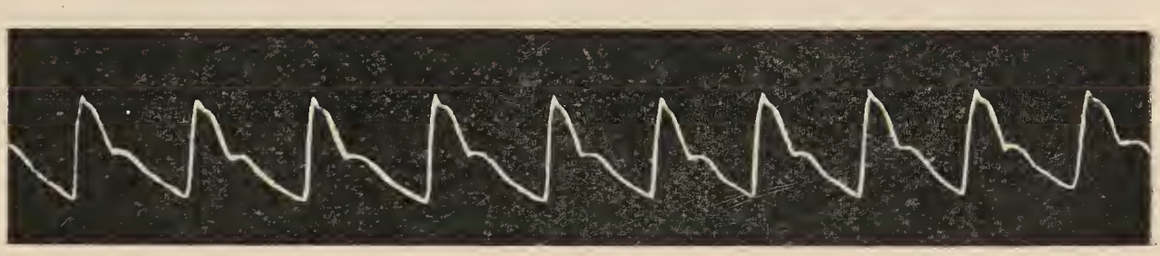

Fig. 4.

C. G., male; pulse, 74; pressure, 4 oz; first stage.

they might almost have been taken from the same subject. In all these examples we note the high and perpendicular upstroke, indicating considerable force in the ventricular systole, but the downstroke is sudden, the fall rapid, and the descent line is marked by a sharply defined dicrotic wave. Such tracings indicate a pulse of low tension. In Fig. 4 the predicrotic notch suggests a tendency to "plateau" formation, and consequently to increase in the tension, but

this tracing was taken in the later period of the first stage, but before the onset of the second stage. Fig. 5 was obtained from a woman—an alcoholic case—well mentally, but with suspicious twitchings of the facial and labial muscles.

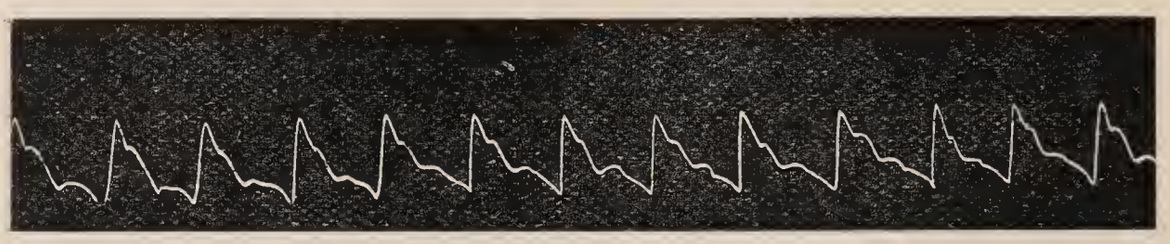

Fig. 5.

S. J. N., female ; pulse, 104 ; pressure, 4¼ oz. ; alcoholic case.

This tracing might be considered as a perfectly normal one with a fair amount of tension. Fig. 6 was obtained from a syphilitic case, undoubtedly a general paralytic in the early stage, and here tension is more marked than in any

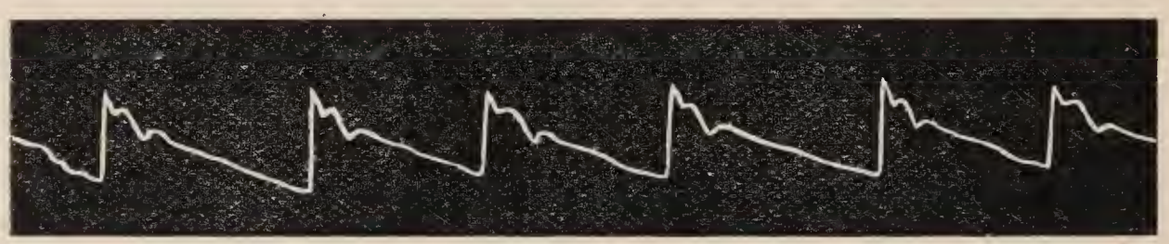

Fig. 6.

J. S., male ; pulse, 64 ; pressure, 4¼ oz. ; syphilitic case.

of the other tracings illustrating this stage, proving that syphilitic endarteritis, by constricting the lumen of the arteries, is the main factor in the production of high tension in these cases, even in the earliest stages of the disease.

Second stage.—In this stage of general paralysis the patient presents most of the motor, but fewer of the mental, symptoms that characterise the first stage. The mental symptoms, although still present, are not so pronounced as they were, and the patient tends to lead a quieter and more facile life than he did. The mental storm is succeeded by a quiet period, during which he is liable to become fat. To the finger the pulse is slow and hard, and considerable resistance is offered to digital pressure. The sphygmogram indicates high tension, the upstroke is rarely so high as is usual in the first stage, showing a considerable enfeebling of the ventricular systole, while the downstroke is sustained so that, in a typical case, a

"plateau" is formed, it may be without any predicrotic notch at all, or this latter may be only slightly marked, as seen in Fig. 7.

The progress of the disease induces two important pathological factors:—(1) A peripheral resistance to the blood-stream, and (2) a compensatory hypertrophy of the vascular walls, and these two factors no doubt explain the characteristics of the pulse-tracing at this stage of the disease; the resistance to the

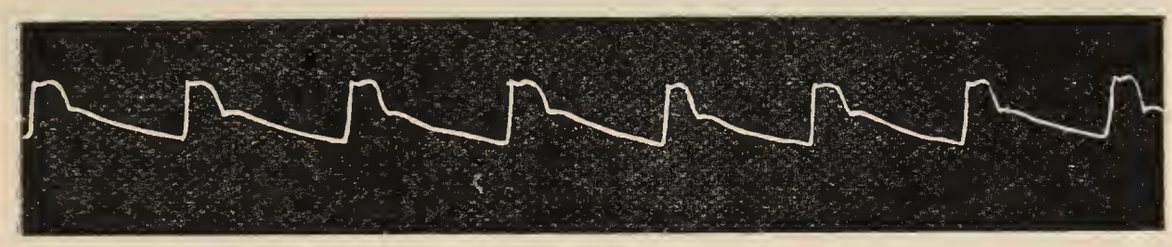

Fig. 7.

F. C., male; pulse, 80; pressure, 3½ oz.; second stage.

peripheral circulation causes the lever of the instrument to be sustained, so that the downstroke is delayed and prolonged. A modified *pulsus bisferiens* is sometimes observed during this stage, and is another indication of increased arterial tension.

Fig. 8 was taken from a mildly demented general paralytic, quiet, but with delusions of exaltation, and the disease was afterwards verified by *post-mortem* examination.

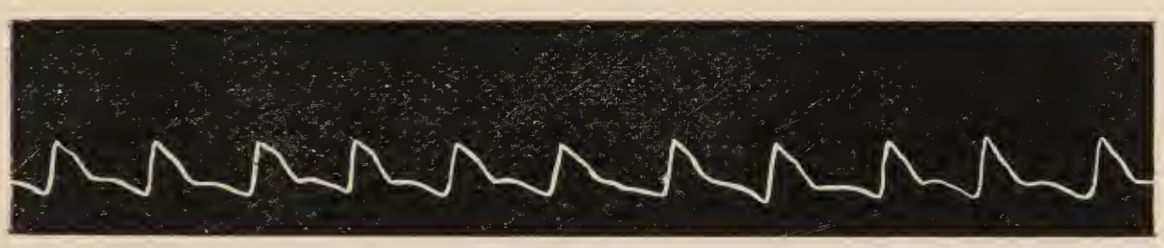

Fig. 8.

C. W., male; pulse, 86; pressure, 2½ oz.; second stage.

Fig. 9 (p. 18) is the tracing from the pulse of a restless and dirty paralytic in the second stage of the disease, and it shows typical high tension.

It is towards the termination of this stage that the pulse tracing supposed by the late Dr. Thompson to be characteristic of general paralysis is found, and Fig. 10 (p. 18) illustrates this type. The upstroke is low, indicating rather a weak systole, and the descent line is prolonged and interrupted by a number of wavelets, 5 to 8 according to Thompson, but never

more than 4 to 5 in any tracing I have taken. One would almost imagine that the tremors, so common to the *voluntary* muscular system in general paralysis, had also, in these cases, invaded the *involuntary* muscular fibres which form the tunica muscularis of the artery, giving a tremulous shaking to

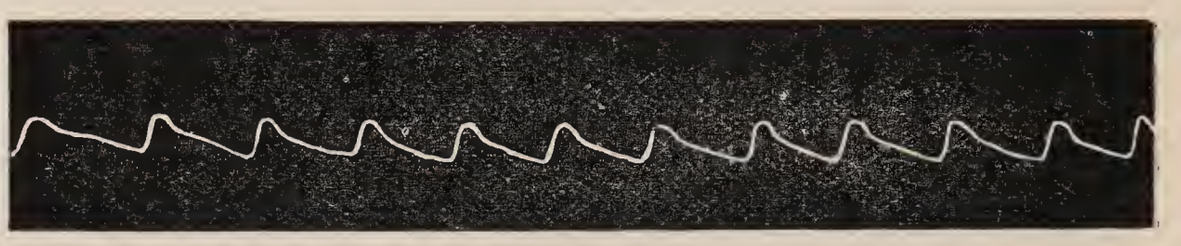

Fig. 9.

T. C., male ; pulse, 86 ; pressure, 4¼ oz. ; second stage.

the lever of the sphygmograph while the descent line is being recorded. This type of sphygmogram, however, is rare—too rare to be considered as typical of the "compound disease" general paralysis, and in hundreds of tracings I have only found it in several cases. I would consider it merely as a

Fig. 10.

J. G., male ; pulse, 80 ; pressure, 4 oz. ; second stage.

variety, occurring in cases where the motor symptoms were specially well marked.

The gradation into the third stage of the disease may be sudden, as by the onset of epileptiform or apoplectiform seizures—commonly called "congestive" seizures—or by a steady decline of the mental and physical systems, and, as might be expected, the pulse-tracing varies accordingly. There is a lowering of the upstroke as the disease progresses until the characteristic tracing of the last stage is fully developed.

Third stage.—In this, the last stage in the history of general paralysis, dementia is complete, the patient is bedridden, and the breakdown in health—both mental and physical—is, as a rule, most rapid. Emaciation becomes extreme, and bedsores and abscesses tend to form, "congestive" seizures hasten the

fatal end, or the patient may slowly die from exhaustion. Leucocytosis, erratic rises of temperature, and other symptoms indicating blood-poisoning, probably bacterial in nature, are likewise common symptoms during this stage.

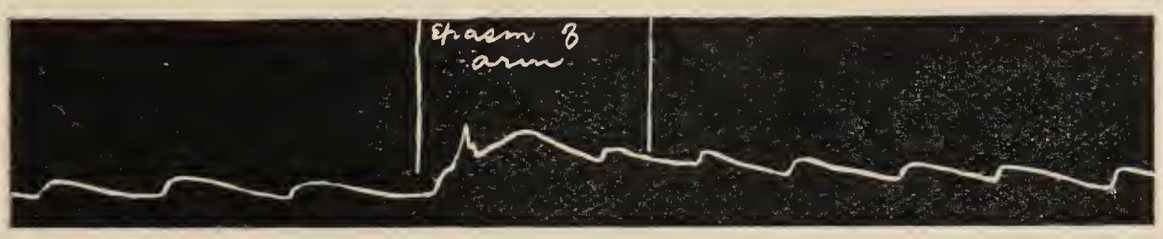

FIG. 11.

J. W., male; pulse, 92; pressure, 2½ oz.; last stage; moribund and dying from congestive seizures.

The heart's action is now extremely feeble, muscular hypertrophy is no longer compensatory, and the continued peripheral resistance to the circulation becomes exaggerated in intensity,

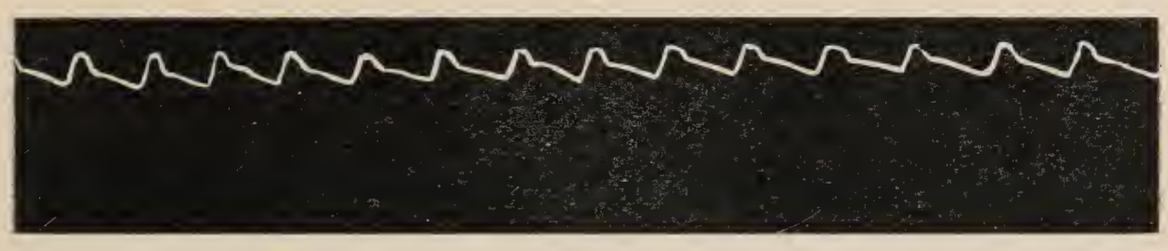

FIG. 12.

J. R., male; right hemiplegia; last stage; pulse, 100; pressure used, 2½ oz.

so that, while the ventricular systole is now markedly enfeebled, arterial tension is maintained or even increased.

The characters of the pulse-tracings in this stage are a low

FIG. 13.

W. G., male, æt. 38; last stage; pulse, 90; pressure, 4 oz.

and sloping ascent line, the apex generally rounded, and the descent line prolonged and usually comparatively free from notches or wavelets. Fig. 11 was taken from a general paralytic who died thirty minutes afterwards—the irregularity

being due to an interruption caused by a congestive (convulsive) seizure, which occurred while the tracing was being taken. Fig. 12 (p. 19) is from a bedridden paralytic who died several days afterwards, and who had seizures, followed by total paralysis of his right side and bladder; the tracing suggests a feeble systole, but with indications of continued arterial tension. A tracing taken several months previously in this case, showed high tension with "plateau" formation, and with a perpendicular and high ascent line—the type characteristic of the second stage. Fig. 13 (p. 19) is the tracing of a bedridden paralytic slowly dying from exhaustion.

In conclusion, it may be safely said that a consideration of the heart, blood-vessels, and the pulse in general paralysis indicates the directions in which any investigation, having for its object the elucidation of the etiology and pathology of this disease, should take.

Modern scientists are, it is to be feared, given too much to ascribing the ultimate cause of all disease to "germs," even before they have thoroughly mastered the grosser lesions and ascertained the *rôle* these play in its etiology. Hitherto we have been content to maintain that all disease is caused by cellular modifications, but it would appear as if cellular pathology were a thing of the past, and that, by the use of high magnifying powers, the microscope is revealing to us the ultimate causes of disease to be minute organisms, each of which appears to have its antagonist in the battle of germ life!

If we are to admit that general paralysis is due to bacillus infection, are we any nearer the goal of our hopes—the discovery of a specific? Is there a method of existence in this busy world of ours—apart from escaping syphilis—whereby we can avoid contracting this disease? and if not, then as by inoculation we may escape some diseases, do the adherents of the bacillus theory hold out any prospects that thereby is our salvation, and by this means will we escape so direful a malady?

Until a satisfactory answer is forthcoming we must be content to waive all dogmatic statements, and continue to prosecute our investigations with the light we already possess; it may be that in time pathology will render effectual assistance in the prevention of disease, and we will hope that general paralysis, that hitherto invariably fatal malady, will be among the first of diseases to disappear when inoculation becomes the fashion!